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Ambiguity resolution of the dative Np in Korean.

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AMBIGUITY RESOLUTION OF THE DATIVE NP IN KOREAN

A Thesis Presented

by

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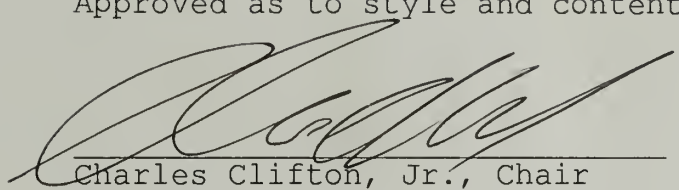

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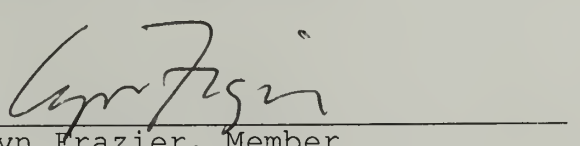

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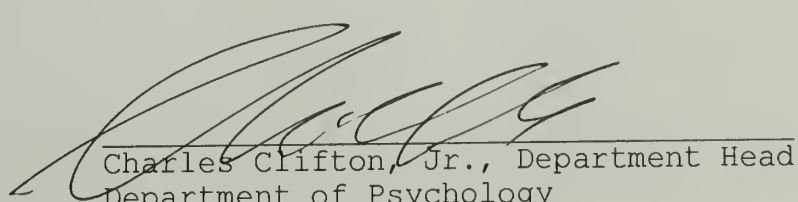

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CHAPTER I

INTRODUCTION

Is the language processor constant across languages with very different typological properties? If so, what is its design? How can a universal language processor reflect different grammars?

When theorizing about a universal parser, the first task to do must be to investigate the relation between a grammar and a parser. Views on this relation could roughly be divided into 'direct' and 'mediated' views. The 'direct' view claims a transparent relation between a grammar and a parser, which means that grammar modules strongly constrain syntactic parsing. On the other hand, the 'mediated' view claims that phrase-structure rules, which may be viewed as integrated reflections of grammar modules, guide syntactic processing.

In the present study, syntactic parsing theories such as the garden-path theory (Frazier, 1978; Frazier and Rayner, 1982), the lexical-driven theory (Abney 1989; Pritchett 1988, 1991), and a deterministic theory (Weinberg, 1993) will be reviewed. These theories are mainly based on English. Two theories, the garden-path and the lexical-based theory, which represent views on the relation between a

grammar and a parser, will be tested in Korean, which has a different grammar from English.

A. Two Issues in Syntactic Processing

The main goal in studies of syntactic processing is to establish the relationship among a variety of sources of information such as lexical information, syntactic-structure rules, discourse models and so on. In order to achieve this goal, many studies of language processing since the late 1970s have been concerned with two issues. Fundamentally, the two issues concern the modularity of the syntactic processor. The first issue concerns the relationship between the language system and other cognitive systems. The focus of interest has been whether other cognitive systems can influence 'initial' decisions based on syntactic rules. The second issue concerns what kinds of linguistic subsystems are necessary and what is the relationship among linguistic subsystems (see Frazier, 1991). This issue is connected with the view about the relation between a parser and a grammar. The focus of this issue has been on what kind of linguistic information guides initial syntactic processing.

Fodor (1983) proposed that each system which is in charge of each function could be characterized as either an

'input system' or a 'central process.' He put forward the perceptual and language systems as the representative input modules that have such important properties as domain-specificity, information encapsulation, and speed. A specific input system is used in the specific domain which requires its idiosyncratic computations. Information encapsulation states that an input system is not directly affected by information from distinct domains including central processes. The central system acts on the products of input systems, but its specific processes are not clear since Fodor's view does not specify the interface between cognitive systems and language systems such as the thematic processor. His claim triggered an argument about the modularity of language comprehension. In studies of language comprehension, the "Amherst group," who proposed the garden-path theory, represent the modular view. They proposed that language comprehension, especially syntactic processing, is such that phrase structure rules are applied to the input word without the influence of higher information such as word meaning or context (Rayner, Carlson and Frazier 1983; Ferreira and Clifton, 1986; Clifton and Ferreira, 1987). The "interactive" views assume that when information is available it can influence immediate comprehension, whatever the information is (Crain and

Steedman, 1985; Marslen-Wilson and Tyler, 1987; Marslen-Wilson, Tyler and Koster, 1993). In sum, the critical difference between two views is whether higher information such as the meaning of words and the discourse model can affect initial syntactic structure building.

Another issue concerns the relationship between grammars and the language processor. This problem is involved with what kind of linguistic knowledge guides syntactic processing. The 'direct' view claims that the syntactic processor directly and strongly reflects the grammar, especially the principles of government-binding theory which constitute grammar modules like theta theory, X-bar theory and case theory (Abney, 1989; Pritchett 1988, 1991; Weinberg 1993). On the other hand, the garden-path view claims that syntactic processing is based on phrase-structure rules that describe the relation among the constituents in a phrase marker. These phrase structure rules can be considered as precomplied consequence of grammar modules (Frazier 1989).

The direct and current problems in relation to a universal parser are mainly involved with the second issue. More specifically, the problem is how current parsing theories can be applied to languages with different typological properties. In addition, which theory is more

appropriate in accounting for the syntactic processing of head-final languages? Before we review each theory, and look at the application of it to Korean and the prediction for the specific conditions, I will review the syntactic properties of Korean.

B. Korean Grammar-Focus on the Difference between Korean and English

Korean has a well-developed morphology. Verbal morphology clearly represents most grammatical functions such as passive, causative, tense, and mood. Also there are two types of clause ending markers, argument clause and adjunct clause. The complementizer (ko, tolok) belongs to the former, and the relative clause marker ((u)n) and adverbial clause markers (umyen (if), ciman (though), se(because), kose (after)) belong to the latter. Also, the coordinate conjunction is realized as the conjunction marker (ko).

In Korean, nominals do not show declension for person, number, gender, and case. The case markers and postpositions, which are enclitic to a preceding nominal, represent the grammatical role of nominals. There are case markers such as the nominative (ka, I), the accusative (ul,

lul), the genitive (uy) and the dative (eykey)[1]. The form of a given case marker depends on phonology. Though case markers do not head their maximal projections, a postposition assigns case to a preceding nominal and heads its own maximal projection. There are a variety of postpositions such as locative (ey, eyse), instrumental (lo, losse), source (eykeyse, lopwute), and temporal (ey).

1. Head-final Property and Left-branching

The most distinctive property of Korean is its head-final nature. Lexical and functional heads occur in the final position of phrases. A lexical head such as the verb in a verb phrase or the noun in a noun phrase is always in the final position. As a result, theta role assignments, which are mainly based on verb information, can be made only in the final position of each clause. Let us consider the simple sentence (1).

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[1] Suh (1995) claimed that the dative case marker as a postposition to account for the difference between the accusative and the dative marker. One fact is that the accusative marker can be deleted when the accusative marked NP is adjacent to a verb. But the dative marker cannot be deleted.

(1)Korean: sonen-I sone-lul coahayssda.

"boy-Nom girl-Acc liked."

English:The boy liked the girl.

In (1), we see that the verb, *coahayssda*, which is the head of the verb phrase, occurs in the final position of a verb phrase.

In Korean, the modifier clause appears before the modifee.

The relative head occurs after the relative clause. Let's consider the sentence (2).

(2) Korean:na-ka [sone-lul coaha-nun] sonen-ul anda.

"I-Nom [girl-Acc like-rel] boy-Acc know"

English:I know the boy that likes the girl.

In example (2), we can see that the relative clause occurs before the relative head, *sonen-ul*. Usually, this left-branching property makes it difficult to know whether the first noun phrase belongs to the main or subordinate clause until the relative verb or the relative head. Furthermore, if the first NP belongs to the main clause, the distance between the first NP and the second NP is theoretically infinite because of the recursive rule of branching.

2. Scrambling

The verb in Korean strictly occurs in the final position of each sentence. In contrast, arguments and modifiers have free order within each clause and less commonly, across a clause boundary (Inoue and Fodor, 1994). Consider (3). In (3b), the NP-Acc, *sone-lul* is located before the NP-Nom, *sonen-I*.

(3) Korean: a.sonen-I sone-lul coahassda.
"boy-Nom girl-Acc liked."
b.sone-lul sonen-I coahassda.
"girl-Acc boy-Nom liked."
English: The boy likes the girl.

3. Pro-drop

Any argument can be dropped in Korean if contextual information can fill it. Let's consider (4).

(4) Korean :(ku) kakey-ey kassda.
"(he) store-postposition went."
English: He went to the store.

In (4), because context guarantees that the 'agent' of the verb, *went*, is a specific referent, the pronoun, *ku*, can be dropped.

C. Views on What Information Guides the Initial Syntactic Analysis

We can divide theories on the basis of their view of the relation between grammars and the syntactic processor. The garden-path theory assumes that phrase-structure rules are immediately applied to the input word and these phrase-structure rules are based on the precompilation of grammar modules. An information paced approach is very similar to the garden-path theory in that the first pass processing is based on principles that can be characterized as minimal cost, like minimal attachment. On the other hand, lexical-based approaches and the deterministic theory claim that grammar modules must be directly applied to syntactic processing, which means that lexical information, especially information provided by a head, is very crucial in the syntactic structure building because the head provides the information about complements. With respect to head-final languages, lexical-based theory and the deterministic theory

are different in that the latter claims that case markers play a role as internal licensors, which means that a case marker can support the projection of a phrase node (Weinberg, 1993). For example, the nominative marker (ka, I in Korean) can support an IP node, and the accusative (ul, lul) and the dative marker (eykey) can be a VP node.

1. Garden-path Theory

This is a very traditional theory in the study of syntactic processing in that it has motivated many studies that concentrate on the resolution of local ambiguity of language. This theory assumes that the syntactic parser uses phrase-structure rules that consist of syntactic constants and does not include syntactic variables.

In this theory, syntactic processing consists of two phases. The first phase is concerned with accessing the syntactic category of a word, which may be a necessary condition to apply phrase-structure rules to input. When the syntactic category of a word is ambiguous (syntactic category ambiguity), the attachment of input is delayed until the syntactic category is clear (Frazier and Rayner, 1987). As soon as the syntactic category is identified, the input word is immediately attached to the current phrase

marker in ways specified by phrase-structure rules. In this second phase, which consists of rule application processes, the parser often encounters ambiguities. Let's assume a simple version of the phrase-structure rules for English (5).

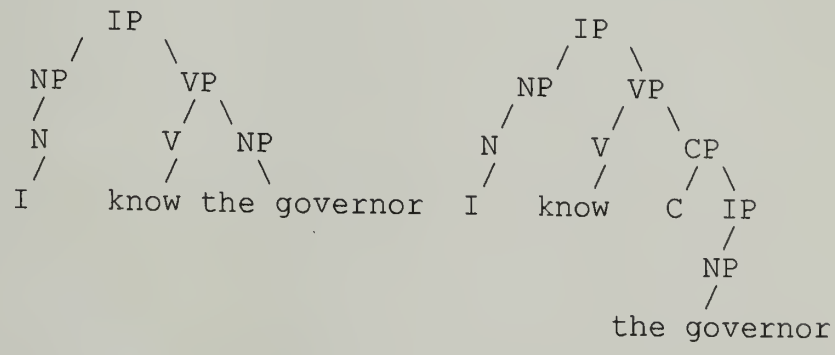
(5) a. CP-> C IP
b. IP-> NP I'
c. I'-> I VP
d. VP-> V (NP) (PP) (CP)
e. NP->(DET) N (PP)
f. PP->P (NP)

Let's consider the sentence (6).

(6) a. I know the governor is sick.
b. After he drank the water tasted bad.

When *the governor* is read in (6a), NP is assumed to be projected. The problem is that two expansions of rule (5d), which are 'V NP' and 'V CP', can be applied to this input. Let's look at the current phrase marker of the sentence (6a) before the verb, *is*, is encountered (Fig 1). If one expansion of (5d),'V NP' is applied to this input, this input can be attached to this current phrase node as the

object of the verb without the postulation of any other node. If the other expansion, 'V CP' is applied to this input, a 'CP' node must be postulated and the input taken as subject of its IP complement(see Fig 1).



a.expansion of 'V NP' b.expansion of 'V CP'

Fig 1) The two possible partial phrase markers before the verb, 'is' is encountered in the sentence (6a)

This theory assumes that the parser observes the 'minimal attachment' principle, which states that the parser should attach the incoming material into the phrase-marker being constructed using the fewest nodes consistent with the well-formedness rules of language being parsed (Frazier, 1978; Frazier and Rayner 1982). Minimal attachment favors the former analysis. Hence, revision is required when the embedded verb, *is,* is encountered in the sentence (6a).

The other problem involves the closure of the current phrase. Let's look at (6b). When *the water* is encountered, if the VP node that is based on *drank* has been closed (early

closure), *the water* cannot be attached to VP as an object. The garden-path theory assumes the late closure principle, which states that when possible, the parser attaches incoming material into the clause or the phrase currently being parsed (Frazier and Rayner 1982). According to this principle, *the water* is initially attached to the 'VP' node and later revision occurs when the main verb, *was*, is encountered. The late closure principle is similar to right association in Kimball's parser (Kimball, 1973).

The syntactic representation based on these two principles will then be compared with thematic or semantic information. If the thematic or semantic information signals an error, the parser does reanalysis.

2. Information-paced Approach

Inoue and Fodor (1994) proposed an "information-paced" theory. Within this theory, parsing processes consist of two phases. The first phase is to build the initial syntactic structure on the basis of minimal attachment or right association without delay. This distinctive quality of this phase is that all possible alternative analyses are logged in at each choice point, though only one analysis is developed in subsequent processing. The second phase is the

revision process. This revision is based on the 'confidence' of the first analysis. This confidence is determined by the strength of the alternative analysis. If the confidence of the first analysis is low, the revision is easily made. Inoue and Fodor (1994) proposed the 'Thematic Overlay' effect in order to account for weak and strong garden paths. Usually revision involves movement of constituents. If a constituent is assigned a new thematic role, processing difficulty can result unless that constituent's previous thematic role is overlaid by other constituent's, erasing the previous semantic interpretation.

(7) a.John expected the water to taste bad. (Very mild)
b.After John drank the water tasted bad. (Severe)

In (7a), when *the water* is encountered, it is considered to the object of the verb, *expect*. Later, when the main verb, *tasted* is encountered, *the water* becomes a subject of *tasted*. In this revision, the original thematic role of *water* that is a theme, should be overlaid by the sentential complement. However, in (7b), the previous thematic role of *the water* is not overlaid, although revision is very similar in (7a) and (7b). As a result, the processing of (7b) is predicted to be harder than that of (7a).

3. Lexical-based Approach

As said before, this approach assumes that syntactic processing directly reflects grammar modules like theta theory, X-bar theory, and case theory (Abney, 1989; Pritchett, 1988, 1991; Weinberg, 1993). X-bar theory guarantees the projection of the corresponding phrase when a head is given. For example, if input is known to be a noun, an NP is projected (8).

(8) The diagram of X-bar theory

XP -> (AP) X'

X'-> X' (BP)

X'-> X (YP) (ZP)

However, X-bar theory itself cannot provide the relation of each phrase to the head. This information is assumed to be stored in each word. Especially, a theta assigner like a verb contains complement information (9).

(9) put: Agent < theme location>

NP NP PP

Within lexical-based theory, this lexical information guides

initial syntactic parsing. Let's look at some specific theories.

Abney (1989) proposed a computational model of parsing (licensing structure parser, LS parser). According to him, a bottom-up parser (LR parser) can build no structure in right-branching structures until all the words of each phrase have been read. He claimed that such a parser cannot meet the incremental constraint. On the other hand, a top-down parser (LL parser) can produce unnecessary nodes from insufficient information. To avoid these problems, his parser is based on government-binding principles. In his parser, the action based on X-bar theory is called 'Shift', and the action based on theta theory is called 'Attachment'. He considered local ambiguities to be conflicts between which action to take next. He proposed the following preference strategies when two attachments are in conflict.

P1 : prefer theta attachment to non-theta attachment

P2 : prefer attachment to verbs over attachment to nonverbs

P3 : prefer low attachment.

Pritchett (1988, 1991) proposed that syntactic parsing is based on the grammar. Specifically, the syntactic parser

maximally satisfies the grammar at every point during a parse. Also, the grammar constrains syntactic reanalysis. Let us look at (10).

(10) a. Without her contributions we failed.

b. Without her contributions failed.

In the example above, since *without* is a theta assigner, *her* can be interpreted as an NP that fills the thematic role. When *contributions* is read, it is identified as the head of the NP, which is based on X-bar theory. As the parser tries to satisfy the grammar, especially the theta criterion here, this NP receives the theta role from *without* which had initially been assigned to *her*. This analysis is acceptable in (10a), but in (10b), *contributions,* must be reanalyzed as subject of the verb, *fail*. Pritchett proposed that when reanalysis violates a constraint that is based on the grammar, it produces reprocessing difficulty. The constraint is the following (Pritchett, 1988).

(11)a.Theta Reanalysis Constraint:

Syntactic reanalysis which interprets a theta-marked constituent as outside its current theta-domain is costly

b.theta-domain: α is in the γ theta-domain of b iff α receives the γ theta-role from β or α is dominated by a constituent that receives the γ theta-role from β.

This constraint predicts that reanalysis of some minimal-attachment type sentences is not difficult. Let's consider (2a) (discussed earlier).

(2a) I know the governor is sick.

The sentence (2a) requires that the NP *the governor* is reanalyzed as the subject of *is*, not the object of *know*. According to Pritchett's reanalysis constraint, this reanalysis does not produce reprocessing difficulty, because the NP, *the governor* is still in the same theta domain of *know* (weak garden path). On the other hand, the reanalysis of the sentence (10b) leads to processing difficulty, because the theta domain of *contributions* should be changed from the domain of *without* to the domain of *fail* (strong garden path). Pritchett's idea of a reanalysis constraint seems to have influenced later theories such as Inoue and Fodor's (1994) and Weinberg's (1993) theory.

With respect to head-final languages, Pritchett (1991) noted that processing difficulty is not easily observed in Japanese sentences. He claimed that this fact reflects the head-final property of Japanese. That is, parsing is delayed until a head is encountered. Especially, the relation among arguments cannot be calculated before a verb is read.

However, the processes of theta-role assignment are not specified, especially in head-final languages. Let's consider (3) again. When the verb 'like' is encountered in (3), how can 'boy' be assigned to its thematic role, 'experiencer'? The position information in the theta grid of the verb 'like' where the experiencer role appears before the 'stimulus' role cannot account for the interpretation of (3b) which is the scrambled sentence of (3a). In addition, lexical information of each NP such as 'animacy' cannot account for the contrast between (3a) and (3b), since both 'boy' and 'girl' can be an experiencer or a stimulus. In the example above, the case information of each argument might account for (3a) and (3b) if it is assumed that the subject marker is connected with 'agent' or 'experiencer' and the object marker is connected with 'stimulus,' or 'object'.

(3) a. sonen-I sonen-ul choahassda.

"boy-Nom girl-Acc liked"

b. sonen-ul sonen-I choahassda.

"girl-Acc boy-Nom liked"

However, case information may not account for assignment of theta roles to double-Nominative sentences. Let's consider (12). The two sentences of (12) have two nominative NPs. The verb (12a) and the adjectives (12b) are one-place predicates. In (12), the case marker cannot by itself determine to which NP the verb or the adjective assigns a theta role.

(12) a.John-I apeci-ka cukessta.

John-Nom father-Nom died

"John's father died."

b.John-I ton-I manhta.

John-Nom money-Nom a lot

"Johh has a lot of money."

In (12a), the problem is how we understand that the dead person is *father*, not *John*. Establishing a relation between John and father is necessary, by interpreting the nominative marker in *John-I* as genitive. In (12b), in contrast, the

relation between *John* and *money* is one in which the first nominative maker in *John-I* seems to correspond to the locative or dative role. In sum, it is not easy to assign theta roles to each NP from only one type of information. Within the current lexical-based theory, it may be that the contents of the theta grid and case information should be consulted jointly, when theta roles are assigned in head-final languages.

4. Deterministic Theory

Weinberg (1993) proposed the minimal commitment theory. Her theory is based on government-binding theory like Pritchett's lexical-based approach. The main difference from lexical-based theory is that Weinberg's theory follows the monotonic constraint. The monotonic constraint states that a parser can add to an analysis that it is building at any point but cannot cancel previous hypotheses. In the early 1980s, Marcus (1980) proposed a 'look-ahead' algorithm to achieve this constraint. However, later research (Frazier and Rayner, 1982) showed that readers chose an initial reading for temporarily ambiguous sentences, regardless of whether 'look-ahead' is available to disambiguate the relevant structure. Marcus (1987; Marcus and Hindle, 1990)

satisfied the deterministic constraint by proposing a descriptive representation, not a full syntactic tree, as the initial output of the parser.

In a similar vein, Weinberg (1993) proposed an underspecified representation where dominance relations and precedence relations among nodes are directly indicated but where immediate dominance or precedence is inferred indirectly by checking whether there are other dominance or precedence relations between two categories. Let's take a look at (13). Weinberg claimed that when *the governor* is read, the dominance relations like (13) up to this region are built. In (13), 'D(VP, V(know), NP(the governor))' represents that the VP node dominates the V and NP.

(13) I know the governor . . .
D(IP, NP, I')
D(I', VP)
D(VP, V(know), NP(the governor))

Later, even if 'the governor' turns out to be the subject of a sentential complement, the parser would only add more dominance statements indicating that the NP is dominated not only by the VP but also by an intervening sentential complement. That is, it does not require the previous

dominance or precedence relations to be canceled. Consequently, this revision does not lead to processing difficulty.

On the other hand, the revision of a late closure type sentence requires cancellation of the previous dominance relation. Let's consider the previous example (5b)

(5b) After he drank the water tasted bad.

In this example, *the water* is initially attached as object of *drank*. Later, *the water* becomes the subject of the main verb, *was*. Hence, the previous dominance relation, (VP, V(drank), NP(the water)) must be canceled, leading to processing difficulty. Thus, like Pritchett theory, Weinberg's parser predicts that late closure sentences like (5b) but not minimal attachment sentences like (13) produce parsing difficulty.

With respect to a head-final language, Weinberg (1993) proposed that case markers can act as internal licensors, which means that case markers allow the projection of higher nodes such as a VP. For example, the nominative marker (ka, I in Korean) permits the parser to postulate IP, and the accusative and the dative markers permit the parser to project a VP. This point is different from the lexical-based approach.

With respect to the monotonic constraint in head-final languages, Weinberg (1993) claimed that in contrast with English, shifting a subject from the embedded to the main clause does not produce processing difficulty since this raising does not violate monotonicity. According to Weinberg, a projection of inflection does not dominate the nominative NP because the inflection marker in Japanese is empty (we will look at an example like the 'kureru' type sentence below). However, the raising of other constituents like NP-Acc results in processing difficulty because a VP dominates them.

D. Previous Studies in Head-final Languages

1. Studies Supporting Immediate Attachment

Frazier (1987) tested the predictions of the garden-path theory and the lexical-based theory in Dutch, which has a head-final order. Let's consider (14). The PP, *van Holland* in (14) is ambiguous in that it can either be an argument of a verb or an adjunct of an NP-I. Before the verb is encountered, the minimal attachment principle predicts that PP is attached to a VP because such an attachment requires fewer nodes than the attachment to the NP.

(14) a. dat het meisje van Holland houdt

that the girl from Holland likes

that the girl likes Holland

b. dat het meisje van Holland glimlachte

that the girl from Holland smiled

On the other hand, the lexical-based theory has to predict that PP will be attached to NP if it is assumed that the syntactic representation is built as soon as permitted by the grammar. Frazier (1987) found that the reading times for the final region in (14a) were faster than those for the same region in (14b)[2].

Within a head-driven parsing framework, Scheepers, Hemforth, and Koneieczny (1995) proposed that initial syntactic analysis is based on the availability of the lexical head. If lexical heads are available, the phrase projected by the theta assigner is preferred. If mutiple theta assigners are available, the most recent one is

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[2] Actually, Frazier (1987) showed that the difference between the following constructions.

(1) Ik weet dat de man in Holland investeert.

(2) Ik weet dat de man in Spanje in Holland investeert

She found that the reading times in final frame *in Holland investeert* in (1) was faster than those in (2).

preferred. Scheepers et al (1995) studied ambiguity of an NP in a verb-final clause (15). Specifically, the NP, *der Sängerin* in (15) can serve either as a genitive or a dative NP. Their theory predicted a preference for the genitive interpretation rather than the dative attachment because the lexical head, *der Arzt*, is available when the *der Sängerin* is encountered. This prediction is the opposite to that of the garden-path theory, since attachment of an NP to a VP will produce the minimal number of nodes rather than attachment of an NP to an NP-I. In segment-by-segment presentation method, Hemforth et al (1995) found results supporting garden-path theory. However, they suggested the possibility that the segmentation itself could lead readers to assume that the subject NP and the second NP are not combined. In an eye-tracking study, they found that the first-pass reading times for the VP region in VP attachment condition (15a) were slower than those for the same region in the control condition (15b) but the reading times for the VP's region in NP-attachment condition (15c) was as fast as those in control condition (15d).

(15) experimental sentences of Scheepers et al.(1995)

a. Ambiguous VP-attachment

Daß der Arzt der Sängerin ein Medikament gegeben hat,

That the doctor the singer a medicine given has,

wußte niemand

know nobody

'Nobody knew that the doctor has given a medicine to the singer'

b.unambiguous VP-condition

Daß der Arzt dem Sängerin ein Medikament gegeben hat,

That the doctor the singer a medicine given has,

wußte niemand

know nobody

'Nobody knew that the doctor has given a medicine to the singer'

c.Ambiguous NP-attchment

Daß der Arzt der Sängerin ein Medikament entdeckt hat,

'That the doctor the singer a medicine discovered has,

wußte niemand'

know nobody

'Nobody knew that the doctor of the singer has discovered a medicine'

d.Unambiguous-NP attachment

Daß der Arzt des Sängerin ein Medikament entdeckt hat,

wußte niemand

know nobody

'Nobody knew that the doctor of the singer has discovered a medicine'

In sum, the results of the genitive and the dative NP ambiguity in German are not convergent. Also, the syntactic analysis on the genitive case is not clear, which makes the interpretation of data difficult.

Many studies in Japanese and Korean have been concerned with the reanalysis of a relative clause. Generally the preferred reanalysis of a relative clause has been considered to expel an argument out of the current clause when the relative head is encountered, though Gorrell (1995) claimed that the reanalysis of a relative clause concerns structural insertion. This revision operation is correlated with whether the reanalysis proceeds on the basis of a bottom-up or a top-down principle. In addition, it has been claimed that reanalysis occurs 'minimally'. Within the framework of a top-down principle, the 'minimal revision' of the relative clause indicates that revision should occur at the highest phrase node as far as a grammar admits. This revision theory is called 'minimal expulsion' theory. On the assumption of a bottom-up principle, 'minimal revision' may mean that revision such as lowering or structural insertion should, if possible, occur at the lowest phrase node. This

revision theory is similar to 'maximal expulsion (minimal backtracking)' theory, which Hirose (1994) proposed.

Inoue and Fodor (1994) presented intuitive data in Japanese. Let's consider (16).

(16) a. Bob-ga Mary-ni ringo-o ageta
-Nom -Dat apple-Acc gave

b. Bob-ga Mary-ni [ringo-o tabeta] inu-o ageta.
-Nom -Dat apple-Acc ate dog-Acc gave

In sentence (16a), the verb, *ageta,* permits three arguments to occur before it. However, the relative verb, *tabeta,* in (15b) permits only two arguments and does not permit the dative argument. Therefore, the NP-Nom and the NP-Dat in (16b) cannot both be arguments of the first verb encountered, *tabeta*. According to Inoue & Fodor, Japanese often report some sense of surprise at the verb, *tabeta,* suggesting that arguments are attached into the current phrase tree before the verb is encountered.

Suh (1994) used a rating task to show that processing difficulty generally results from violating the monotonic constraint of a deterministic theory like altering the previous dominance or precedence relations in Korean. Consider example (17).

(17) John-I ku chayk-ul ilko iss-ten ai-lopwute
-Nom -Det book-Acc reading-Rel boy-from
ppayassassta.
snatched
'John snatched the book from the boy who was
reading(it)'

In (17), when *ilko iss-ten*, 'reading' is read, the NP-Nom and NP-Acc are attached to the same clause because the verb, *read*, accepts two arguments. Later, when the relative head is encountered, the NP-Nom (*John-I*) is expelled. Finally, when the matrix verb, *snatched* is encountered, the NP-Acc is stolen from the embedded clause because this verb requires a theme argument. 86% of all sentences of this type sentences were judged to be difficult. Suh (1995) claimed that only the reanalysis of the accusative NP violates the monotonic constraint. On the other hand, this result can indicate that multiple reanalyses in a head-final language lead to comprehension difficulty.

Hirose (1994) proposed that when the relative head is encountered in Japanese, the parser follows minimal backtracking, which means that the minimal number of arguments are kept in a relative clause and the other arguments are expelled out from the relative clause.

Actually this idea is based on off-line data (Hirose, 1994). Specifically, participants were asked to complete sentences like (18) by filling out the relevant verb. Hirose (1994) found the dative verb was preferred rather than the transitive verb as a matrix verb in (18).

(18) Ichiroo-ga Michiko-ni jitensha-o ageta
Name-Nom Name-Dat bike-Acc gave
tomodachi-o...
friend-Acc

Hirose (1995) carried out an on-line study. The constructions has the same struture as those of the off-line study (19).

(19) a. Michiko-ga itoko-ni ring-o ageta shoojo-o
Name-Nom cousin-Dat apple-Acc gave girl-Acc
tomodachi-ni shookaishita.
friend-Dat introduce

b. Michiko-ga ring-o itoko-ni ageta shoojo-o
Name-Nom apple-Acc cousin-Dat gave girl-Acc
tomodachi-ni shookaishita.
friend-Dat introduce

In the sentence above, if the dative NP is attached to the main clause together with the nominative NP, as expected under maximal expulsion, minimal backtracking comprehension difficulty will occur when the second dative NP, *tomodachi-ni,* is encountered, since the first dative NP, itoko-*ni* has to be moved into the relative clause.

However, Hirose found that there was no difference in the reading times in the second dative NP, *tomodachi-ni* between the ambiguous sentence (19a) and the unambiguous sentence (19b). In (19b), the first dative NP appears after the accusative NP, which means that the first dative NP is guaranteed to be a constituent of the relative clause. The results seem to support minimal expulsion theory, which means that the minimal number of arguments are expelled on the basis of a top-down principle when the relative head is encountered. With respect to top-down reanalysis, one interesting question concerns whether scrambling is premitted in the reanalysis, which is one topic of the present study.

2. Studies Supporting Non-immediate Attachment

Mazuka (1991) investigated the processing of empty categories in Japanese. Consider the sentence (20). The

sentence (20) has a *kureru* structure, which states that the main action should be for the benefit of the speaker. The crucial point of this sentence is that the first NP-Nom plays the role of subject of the subordinate clause until *kureru* is encountered. When *kureru* is encountered, readers realize that the subject of the embedded clause should be the speaker and the initial NP is the subject of the matrix verb.

(20) Yuuzin ga moochoo de nyuuin site ita toki
friend nom appendicitis hospitalized was when
mimari ni kite kureru
came to visit
"When I was hospitalized with appendicitis, a friend came to visit me."

Mazuka reported that there was no difference in reading times between the *kureru* sentence and the control sentences. The control sentences were complex ones with adverbial subordinate clauses. Mazuka (1991) suggested that processing of empty categories may be delayed. Later Mazuka and Itoh (1995) claimed that the reanalysis of *kureru* sentences is not costly.

Nagata (1993) also used *kureru* constructions like (20).

As stated above, the problem of this construction is that the first NP-Nom (Yuuzin ga in (20)) plays the role of subject of the embedded clause until *kureru*, which occurs in the final position, is encountered. When readers encounter the 'kureru' in the final position, they learn that the subject of the embedded clause is the speaker and the first NP is the subject of the main clause. The question of Nagata's experiment is whether readers immediately reconstruct the syntactic structure as soon as *kureru* is encountered. To test this, after material was presented 'bunsetsu' by 'bunsetsu' (content word + postposition), readers were asked to identify the subject of a probe verb that was either the embedded verb or the main verb of the presented sentence. Nagata found that it was difficult to identify the subject of the embedded clause immediately after the *kureru* was presented. Even in four sec-delay condition, perfect identification was not obtained. On the basis of this data, Nagata proposed 'unimmediate' construction of the syntactic structure. This result seems inconsistent with the claim of Mazuka and Itoh (1995) that the reanalysis of kureru type sentence is not costly.

E. The Aim of the Present Experiment

The review above allows the comparison of theories in Korean. The garden-path theory does not have to assume different parsing principles between head-initial and head-final languages. The languages differ in phrase-structure rules, not parsing principle. Let's take a look at a simple version of Korean phrase-structure rules (21). The garden-path theory assumes that the parsing of Korean is immediate according to such phrase-structure rules as (21).

(21) CP-> NP-Top IP
IP-> NP-Nom VP
VP->(PP) (NP-Dat) (NP-Acc) V
NP->(AP) N
PP-> NP-Post

On the other hand, the lexical-based theory assumes a delay of attachment until a head is encountered. Pritchett (1991) explicitly proposed the delay of parsing in a head-final language.

The present study will appeal to the ambiguity of the NP-Dat which can belong to either the main or the embedded clause. Let's consider (22).

(22) Four versions of one experimental sentence

a.dative-ambiguous (D-A)condition

emeni-ka eppun maknayddal-eykey [samchon-i

Mother-Nom pretty youngest-daughter-Dat [uncle-Nom

sacwu-n] cha-lul mulyechuessda.

buy-rel] car-Acc handed-down.

"Mother showed to the pretty youngest-daughter the car which uncle bought (for her)."

b.dative-unambiguous (D-UA) condition

emeni-ka [samchon-i sacwu-n] cha-lul eppun

Mother-Nom [uncle-Nom buy-rel] car-Acc pretty

maknayddal-eykey mulyechuessda.

youngest-daughter-Dat handed-down

"Mother showed to the pretty youngest-daughter the car which uncle bought (for her)."

c.transitive-ambiguous (T-A) condition

emeni-ka [eppun maknayddal-eykey samchon-i

Mother-Nom [pretty youngest-daughter-Dat uncle-Nom

sacwu-n] cha-lul coahayssda.

buy-rel] char-Acc liked.

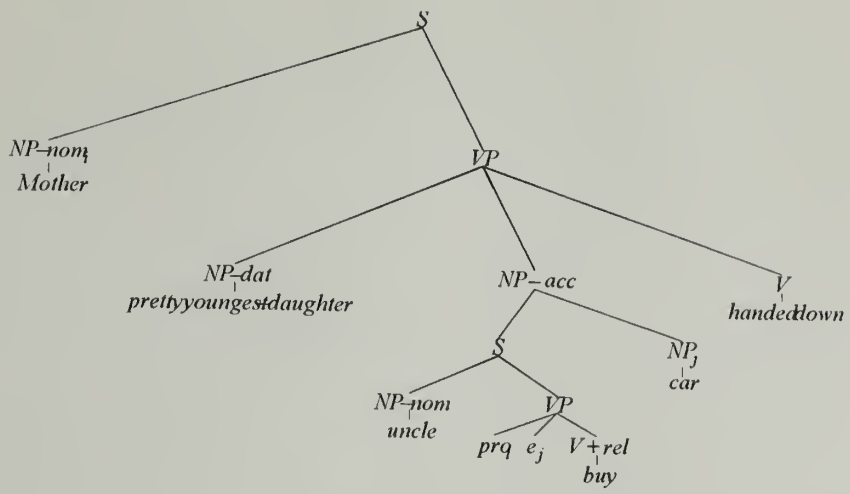
"Mother liked the car which uncle bought for the pretty youngest-daughter."

d.transitive-unambiguous (T-UA) condition

emeni-ka [samchon-i eppun maknayddal-eykey

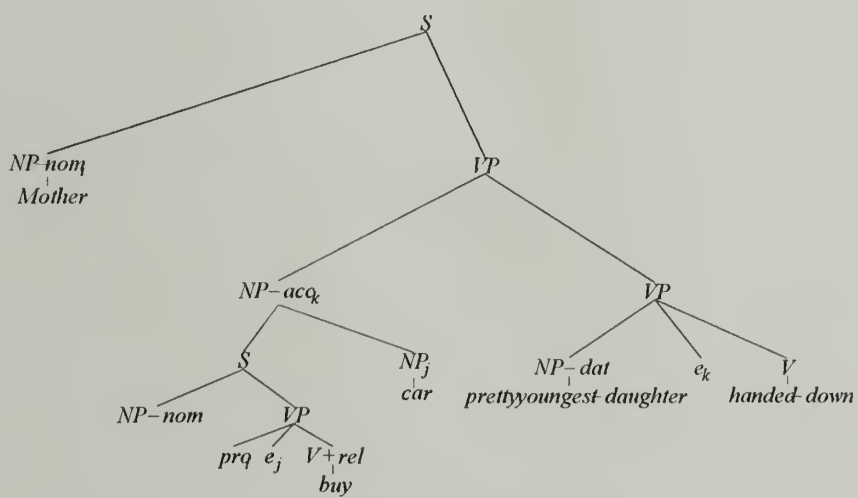
Mother-Nom [uncle-Nom pretty youngest-daughter-Dat sacwu-n] cha-lul coahayssda.
buy-rel] car-Acc liked.
"Mother liked the car which uncle bought for the pretty youngest daughter."

The NP-Dat that is between two nominative NPs (22a and 22c), can be attached to either the main verb or the relative verb. The ambiguity is resolved when the main verb is read. The NP-Dat is an argument of the dative matrix verb in (22a)(dative-ambiguous condition), but an argument of the verb of a relative clause in (22c) which has a transitive main verb (transitive-ambiguous condition). The point of this study is to identify what syntactic representation is constructed before the main verb is encountered by comparing reading times for (22a) and (22c) with their controls, (22b) and (22d). (22b) has the same meaning as (22a) but the NP-Dat is found after the relative head which means that the NP-Dat is always attached to the main clause (dative-unambiguous condition). (22d) has the same meaning as (22c) but the NP-Dat is located between the subject of the relative clause and the relative head, which means that the NP-Dat is always attached to the relative clause (transitive-unambiguous condition).



a.dative-ambiguous (D-A) condition

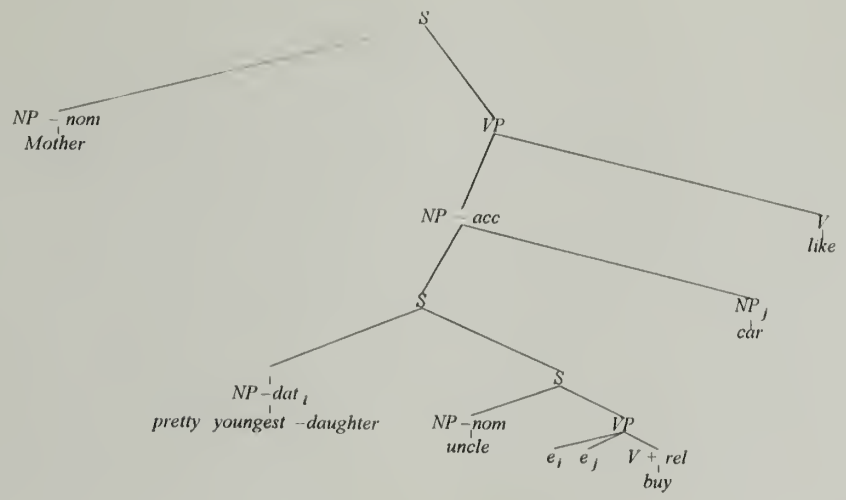
"Mother handed down to the pretty youngest-daughter the car which uncle bought (for her)."



b.dative-unambiguous (D-UA) condition

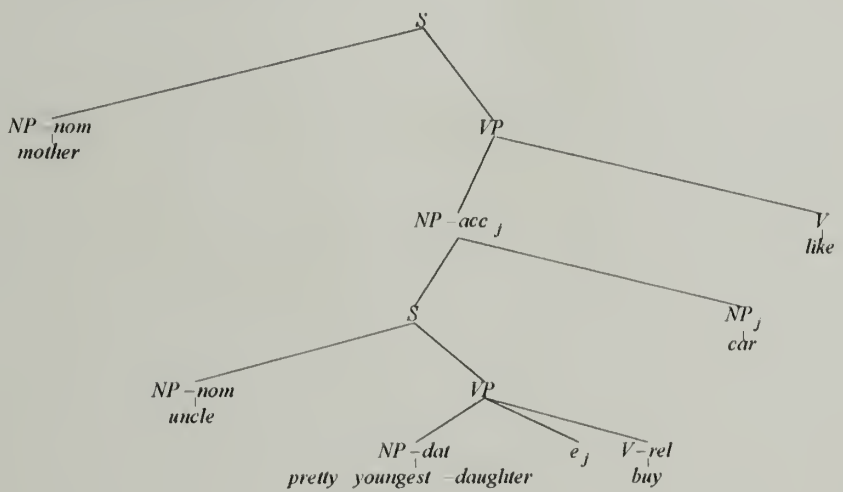
"Mother handed down to the pretty youngest-daughter the car which uncle bought (for her)."

Fig 2) The syntactic representations of four versions of one experimental sentence



c.transitive-ambiguous (T-A) condition

"Mother liked the car which uncle bought for the pretty youngest-daughter."



d.transitive-unambiguous (T-UA) condition

"Mother liked the car which uncle bought for the pretty youngest-daughter."

According to the garden-path theory, when the NP-Dat is encountered in (22a) and (22c), it is immediately attached to the current phrase marker. When the following NP-Nom is encountered, a new subordinate clause (complement or relative clause) is begun. When the relative dative verb is encountered, either the NP-Dat can be taken as filling its dative argument or an empty category can be postulated in dative position. The former action requires both the movement of the NP-Dat from its initial clause into the clause begun by the second NP-Nom and the assumption that scrambling had applied in this clause. The latter (empty element) action permits the NP-Dat to remain in unscrambled position in its clause. If, as we povisionally assume, scrambling and unnecessary expulsion are disfavored relative to postulating an empty category, then the action of positing an empty category inside the second clause will be preferred. In this case, before the matrix verb is encountered, the phrase nodes of the open clause thus consist of an NP-Nom, and NP-Dat, and NP-Acc. If it turns out that the main verb is a 'dative verb' (22a), reprocessing is not required because such a verb accepts three arguments. On the other hand, if the main verb is a transitive verb (22c), the NP-Dat has to be expelled into

the relative clause. Therefore, the garden-path theory predicts that (22a) will be easier than (22c).

According to the lexical-based theory, although the NP nodes can be postulated from the X-bar module, no NP can be attached until a verb is encountered. However, when the verb is encountered, the theta-role assignments may still not be fully specified, as described previously. When the relative verb, *buy*, which appears before the main verb and has thematic information such as agent, goal and theme, is encountered in (22a) and (22c), the parser must attempt to match each NP with each theta-role. Though the theory does not specify matching processes, we can assume that these processes may use the position information of theta grid, and case information to overcome the effects of scrambling.[3]

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[3] Pritchett (1991) proposed that the syntactic structure is the following in (1) when the first verb, syookai suru, is encountered: $[_s\ [_{np}$ Bill ni$]_j\ [_S\ [_{NP}$ Tom ga$]\ [_{VP}\ [_{NP}$ Guy o$]\ e_j\ [_v$ syookai suru$]]]]$

(1) Bill-ni Tom-ga Guy o syookai suru to John wa omotto-iru
Dat Nom something acc introduce IMPF comp John top thinking
"John thinks that Tom will introduce Guy to Bill.

In this structure, Bill-ni is considered as a argument of the verb. So, it is assumed that scrambling is ignored in lexical-based theory.

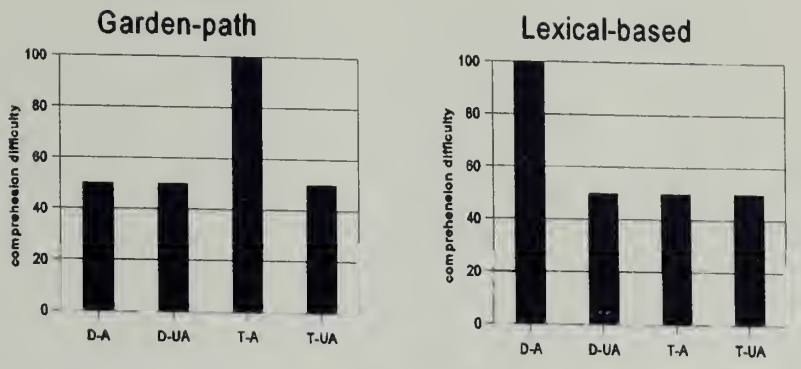

Fig 3) The predictions of the garden-path theory and the lexical-based theory

It seems clear that the second NP-Nom will be assigned to an agent role, and the NP-Dat will be assigned to a goal role. In addition, the first NP-Nom cannot fill any thematic role of the relative verb because the second NP-Nom already fills the subject case-marked position. The relative head, which immediately follows the relative verb, will fill the theme role of the relative verb. Hence, the phrase markers of the main clause are an NP-Nom and a complex NP-Acc before the main verb is encountered. Therefore, the lexical-based theory predicts the opposite of the garden-path theory: (22a) should be harder than (22c). The predictions are presented as Fig 3.

CPAPTER II

EXPERIMENT

A. Method

1. Subject

Twenty-four native Korean speakers were tested. They were paid. Six students could not be lined up.

2. Apparatus

An IBM-compatible computer with a VGA graphics card controlled specific experimental procedures such as presenting sentences, recording times, and saving data. The sentences were presented on a ViewSonic 17G video monitor. In order to measure reading times, the PC was connected with an A-to-D converter, which was connected to a SRI Dual-Pukinje Eye-tracker. To display Korean on a CRT, *Han* which supports a variety of useful functions in grapics mode was used. In this library, one syllable of Korean was represented in a 16 X 16 dot matrix.

3. Materials

Sixteen experimental sentences were constructed with four versions of each. The four versions of each represent the four experimental conditions. The four versions of one sentence are presented below as (22a-d)(repeated from earlier). These sentences had a relative clause whose verb is always an obligatory dative verb. In (22a) and (22b), the matrix verb was an obligatory dative verb, but in (22c) and (22d), the matrix verb was a simple transitive verb. The names of occupations were mainly used as the arguments such as an agent and a goal. Each subject read four sentences in each condition. In addition, thirty-two filler sentences were constructed to prevent subjects from becoming sensitive to the experimental sentences. Sixteen fillers were simple sentences and sixteen fillers were complex ones.

A question followed each sentence. The dative NPs were questioned for the experimental sentences. In (22a) and (22b), the questions were "To whom did mother show the car?" In (22c) and (22d), the questions were "For whom did uncle buy the car?". To prevent readers from becoming sensitive to questions for a dative NP, other arguments or adjuncts were questioned for thirty-two fillers. Specifically, the subject of a sentence was questioned for sixteen fillers that

consisted of eight simple sentences and eight complex ones. For eight fillers, the object of a verb was asked and for eight fillers, the adjunct (e.g.a postpostional phrase) was questioned.

(22) Four versions of one experimental sentence

a.dative-ambiguous (D-A)condition

emeni-ka eppun maknayddal-eykey [samchon-i

Mother-Nom pretty youngest-daughter-Dat [uncle-Nom

NP-Nom ADJ NP-dat [NP-nom

sacwu-n] cha-lul mulyechuessda.

buy-rel] car-Acc handed-down.

Verb] NP-Acc Verb

"Mother showed to the pretty youngest-daughter the car which uncle bought (for her)."

b.dative-unambiguous (D-UA) condition

emeni-ka [samchon-i sacwu-n] cha-lul eppun

Mother-Nom [uncle-Nom buy-rel] car-Acc pretty

NP-Nom NP-nom Verb NP-Acc ADJ

maknayddal-eykey mulyechuessda.

youngest-daughter-Dat handed-down

NP-dat Verb

"Mother showed to the pretty youngest-daughter the car which uncle bought (for her)."

c.transitive-ambiguous (T-A) condition

emeni-ka [eppun maknayddal-eykey samchon-i

Mother-Nom [pretty youngest-daughter-Dat uncle-Nom

NP-Nom ADJ NP-dat NP-Nom

sacwu-n] cha-lul coahayssda.

buy-rel] char-Acc liked.

Verb NP-Acc Verb

"Mother liked the car which uncle bought for the pretty youngest-daughter."

d.transitive-unambiguous (T-UA) condition

emeni-ka [samchon-i eppun maknayddal-eykey

Mother-Nom [uncle-Nom pretty youngest-daughter-Dat

NP-Nom NP-Nom ADJ NP-Dat

sacwu-n] cha-lul coahayssda.

buy-rel] car-Acc liked.

Verb NP-Acc Verb

"Mother liked the car which uncle bought for the pretty youngest daughter."

4. Procedure

Each subject was run individually. When a reader came to the lab, a bite bar was prepared and the functioning of an eye tracker was described. Readers were told that they

should attempt to understand each sentence so that they could answer a question, and that they should press a key when they had read the sentence to their satisfaction. The reader was asked to understand sentences as correctly as possible and as soon as possible. After an initial calibration, which normally took about ten minutes, readers read eight practice sentences presented on a CRT. Before reading a sentence, a brief calibration check was performed. When the reader pressed a key immediately after reading a sentence, a question was presented. Two alternative answers appeared below the question. When the reader chose one, the next trial started. After practice, readers were recalibrated and then the reader began reading the experimental (16) and filler sentences (32), which were randomly ordered for each reader. During reading, the right eye was monitored to measure the start position, the end position and the fixation durations for each fixation of a sentence. When the experiment was done, the reader was told the aims of the present experiment.

5. Prediction

Predictions were presented in Figure 4. The garden-path theory predicts that the reading times at the main verb in

(22a, dative-ambiguous (D-A) condition) and in (22b, dative-unambiguous (D-UA) condition) will be equally rapid. The reading times at the main verb in (22c, transitive-ambiguous (T-A) condition) will be longer than these in (22d, transitive-unambiguous (T-UA) condition). The prediction of the lexical-based theory is the opposite. According to this theory, the reading times at the main verb in (22a, dative-ambiguous condition) will be longer than those in (22b, dative-unambiguous condition). The reading times at the main verb in (22c, transitive-ambiguous condition) and in (22d, non-ambiguous-transitive condition) will not be different.

B. Results

Two subjects were ruled out in data analysis because of unaccurate line-up and a lot of track losses. Individual fixation times under 100ms or over 1000ms were considered to reflect noise and were excluded from data analysis. Also, if the vertical fixation position was higher or lower by three characters, that fixation was ruled out in data analysis.

A variety of reading time measures for each region of each experimental sentence were calculated. For each region, which was the word unit in this experiment, the first-pass,

the second-pass, and the total-reading times, and the regression-out probabilities, were measured. All these measures are presented in Table 1-4. The first-pass reading times, which are reading times before the eye leaves that region forward or backward, are presented in Table 1. The total-pass times are presented in Table 2 and Fig 4 as are the second-pass reading times (Table 3). Table 4 presents several measures for the matrix verb region including the rereading times and regression-out probabilities. Rereading times differ from second-pass times in that rereading times are reading times that readers read the specific region again after the eye leaves that region despite eye movement direction. On the other hand,the second-pass reading times (table 3) are the reading times that readers read the specific region after the eye passes that region.

In the present experiment, the critical disambiguating region was the matrix verb. In Table 4, various reading times and the regression-out probability for the verb are shown. For reading times of the matrix verb, a two-way, matrix verb type (dative vs. transitive) X ambiguity (ambiguous vs. unambiguous), ANOVA was carried out. The reading times of the dative matrix verb were faster than those of the transitive matrix verb in the first-pass reading times $F1(1,15)=4.75$, $p<.05$, the total-pass reading

times *F1*(1,15)=12.23, *p*<.01, *F2*(1,15)=5.88, *p*<.05, and the rereading times *F1*(1,15)=6.52, *p*<.05, *F2*(1,15)=3.79, *p*=.067. Also, regressions occurred in the transitive matrix verb more frequently than in the dative matrix verb, *F1*(1,15)=32.76, *p*<.001, *F2*(1,15)=15.88, *p*<.01 (see Fig 5).

In addition, rereading times of the unambiguous conditions in the main verb region were faster than the ambiguous conditions, *F1*(1,15)=4.55, *p*<.05, *F2*(1,15)=4.91, *p*<.05. In total-reading times, the main effect was significant only in sentence-random, *F2*(1,15)=7.73, *p*<.05, *F1*(1,15)=2,48, p=1.33. However, the interaction between the verb type and the dative NP's ambiguity did not reach any significance in first-pass times, *F1*(1,15)=1.60, *p*=.22, *F2*(1,15)=.39, in total times, *F1*(1,15)=.003, *F2*(1,15)=.25, in regression-out probabilities, *F1*(1,15)=.78, *F2*(1,15)=1.08, *p*=.32, in rereading times, *F1*(1, 15)=1.52, *p*=.24, *F2*(1,15)= 1.07, *p*=.32.

The sentence-comprehension times, the total time between sentence presentation and pressing of the key when the reader understands the sentence and is ready to answer the following question, are presented in Table 5. Only the verb type main effect was significant, *F1*(1,15)=11.94, *p*<.01, with transitive main verbs yielding longer reading time than dative verbs.

With respect to the reanalysis of a relative head and local complexity in the matrix verb region, the dative-ambiguous (D-A) and the transitive-ambiguous (T-A) condition were compared in the matrix verb region. The total reading times in the transitive-ambiguous condition were longer than those in dative-ambiguous condition, $F1(1,15)=4.64$, $p<.05$. Also, regressions arose in the transitive-ambiguous condition more often than in the dative-ambiguous condition, $F1(1,15)=14.89$, $p<.01$, $F2(1,15)=16.68$, $p<.001$. In addition, the dative-ambiguous (22a) and transitive-unambiguous condition (22d) were compared. Nothing was significant in the reading times and regression probability.

Table 1. First-pass times for each region (ms per syllable)

conditions							
D-A	NP-Nom	ADJ	NP-Dat	NP-Nom	V	NP-Acc	V-Dat
	145.09	81.26	78.30	87.40	81.79	73.58	67.83
D-UA	NP-Nom	NP-Nom	V	NP-Acc	ADJ	NP-Dat	V-Dat
	148.96	86.71	87.85	81.84	84.66	74.79	60.18
T-A	NP-Nom	ADJ	NP-Dat	NP-Nom	V	NP-Acc	V-tra
	134.51	86.04	73.91	79.76	84.44	71.97	69.63
T-UA	NP-Nom	NP-Nom	ADJ	NP-Dat	V	NP-Acc	V-tra
	148.39	92.78	91.60	78.72	83.70	77.27	74.70

Table 2. Total reading times for each region (ms per syllable)

conditions							
D-A	NP-Nom	ADJ	NP-Dat	NP-Nom	V	NP-Acc	V-Dat
	206.14	128.36	134.46	125.97	110.24	94.14	82.45
D-UA	NP-Nom	NP-Nom	V	NP-Acc	ADJ	NP-Dat	V-Dat
	228.21	161.05	143.59	109.61	141.64	105.09	69.08
T-A	NP-Nom	ADJ	NP-Dat	NP-Nom	V	NP-Acc	V-tra
	211.68	169.18	156.63	165.59	155.85	119.03	105.19
T-UA	NP-Nom	NP-Nom	ADJ	NP-Dat	V	NP-Acc	V-tra
	240.98	194.35	178.01	142.74	121.93	113.71	92.53

Table 3. Second-pass times (ms per syllable)

conditions						
D-A	NP-Nom	ADJ	NP-Dat	NP-Nom	V	NP-Acc
	64.11	43.05	49.54	38.78	28.83	14.03
D-UA	NP-Nom	NP-Nom	V	NP-Acc	ADJ	NP-Dat
	76.26	60.82	44.95	29.19	47.71	19.24
T-A	NP-Nom	ADJ	NP-Dat	NP-Nom	V	NP-Acc
	77.14	79.52	77.07	72.64	60.39	35.13
T-UA	NP-Nom	NP-Nom	ADJ	NP-Dat	V	NP-Acc
	91.96	97.59	84.35	49.74	37.25	31.73

Table 4. The several measures in the main verb (ms per syllable)

Condition	First pass	Rereading	Total	Regression out (%)
D-A	67.83	12.42	82.45	58
D-UA	60.18	8.70	69.08	56
T-A	69.63	32.30	105.19	91
T-UA	74.70	16.38	92.53	73

Table 5. The sentence-comprehension times(ms)

conditions	RT
Dative-ambiguous	4903
Dative-unambiguous	5194
Transitive-ambiguous	5780
Transitive-unambiguous	6298

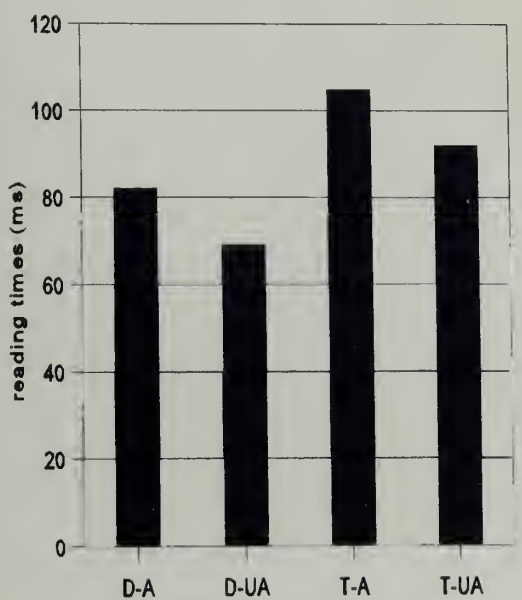

Fig 4) Total reading times

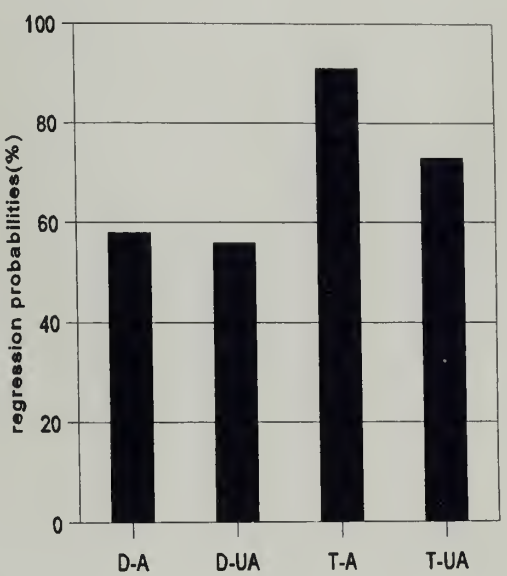

Fig 5) Regression probabilities

CHAPTER III

DISCUSSION

The present experiment did not fully support garden-path theory. That is, the interaction between matrix verb type and the dative NP's ambiguity was not significant. However, the results were very different from the prediction of lexical-based theory in the sense that the transitive-ambiguous condition was not easily compared with the dative-ambiguous condition considering total reading times (82ms vs. 105ms per syllable) and regression-out probability in the matrix verb region (58% vs. 91%).

In the next section, several factors that might influence or confound the reading of the experimental sentences will be considered. Specifically, I will discuss the length effect, which might be the unexpected processing difficulty of the transitive-unambiguous condition compared with the dative-unambiguous condition. This length effect might lead to no interaction between matrix verb type and the dative NP's ambiguity in the present experiment. In addition, I will discuss scrambling with respect to syntactic reanalysis and I will consider the methodological aspect of sentence wrap-up. Also, I will discuss the difference in local complexity between the dative-unambiguous condition and other conditions in the relative

head and the matrix verb region. In the following section, Hirose (1995)'s study will be compared with the present experiment. Her study is very similar to the present study in that both studies concerned the ambiguity of the dative NP. In the third section, the problems concerned with reanalysis in head-final languages will be discussed. Finally, I will propose a future study of whether verb information such as selection restrictions can immediately be used in reanalysis of the relative verb.

A. Possible Factors that could Influence Comprehension in This Experiment

1. Length Effect Combined with Reanalysis

No significant interaction between ambiguity and verb-type was obtained in this experiment. This result might be due to the unexpected processing difficulty of the transitive-unambiguous condition compared with the other control condition, the dative-unambiguous condition. One source of processing difficulty of the transitive-unambiguous condition seems to be the length between the subject of a relative clause and a relative head. This condition has a longer relative clause than the other control condition by two words. Let's consider how length

comprehension processes of the experimental sentences. When the second nominative NP is encountered, it is ambiguous whether this NP is the subject of a sentential complement or that of a relative clause. We can assume that it is preferred to take the simple option, which means that the second nominative NP is considered as the subject of a sentential complement. In English, Crain and Steedman (1985) proposed that readers preferred minimal attachment (sentence complement) for this kind of ambiguous sentence, at least without context. This choice can lead to the garden path. When the relative head is read, the subject of the sentential complement has to be revised into the subject of the relative clause. Frazier & Rayner (1982) found a length effect combined with reanalysis in minimal attachment and late closure sentences in an eye-tracking study. Also, in late closure sentences, Ferreira and Henderson (1991) showed a length effect between the ambiguous head of a relative clause and the disambiguating part (the verb of the main clause). In the present experiment, the longer first pass time in the transitive-unambiguous condition might reflect spillover of this length effect. In short, the length combined with the reanalysis from a sentential complement to a relative clause analysis might increase processing difficulty in the transitive-unambiguous condition(22d) compared with the dative-unambiguous condition(22b) in the present experiment.

A study like the following might be useful to show the difference between the effect of length on a the rel ative clause and on a sentential complement, like (23).

(23) a.emeni-ga ddal-i mandun os-lul
Mother-Nom daughter-Nom make-rel clothes-Acc
chalanghassda.
show-off.
"Mother showed off the clothes that the daughter made."

b.emeni-ga ddal-i achim-e bang-esu
Mother-Nom daughter-Nom morning-post room-post
mandun os-lul chalanghassda.
make-rel clothes-Acc show-off.
"Mother showed off the clothes that the daughter made in the room in the morning.'

c.emeni-ga ddal-i os-lul mandulessda-ko
Mother-Nom daughter-Nom clothes-Acc make-comp
chalanghassda.
show-off.
"Mother showed off that the daughter made the clothes."

d.emeni-ga ddal-i achim-e bang-esu
Mother-Nom daughter-Nom morning-post bang-post

os-lul mandulessda-ko chalanghassda.
clothes-Acc make-comp show-off.
"Mother showed off that the daughter made the clothes in the room in the morning."

In sentences above, (23a) has a short relative clause and (23b) has a long relative clause. On the other hand, (23c) has the short complement clause and (23d) has a long complement clause. If the physical length affects the ease of revising the sentential complement into the relative clause, it should be found that the reading times of the relative head in the long relative clause would be longer than those of the relative head in the short clause. However, the reading times of the verb including the complementizer would not be different in the two complement clauses.

2. Scrambling

One possible factor to influence reading times may be free word order, which is one property of Korean, as seen earlier. In the present experiment, the main clause of the dative-unambiguous condition (22b) and the relative clause of the transitive-ambiguous condition (22c) were scrambled. If scrambling is a crucial factor, it is predicted that

reading times of the verb region or of a whole sentence in the two scrambled conditions should be longer than those of the unscrambled conditions (the dative-ambiguous and the transitive-unambiguous condition). The results do not seem to support this prediction in reading times of the verb region of the scrambled clause, as seen earlier. Also, the total-sentence comprehension times of the dative matrix conditions were faster that those of the transitive conditions (5048ms vs. 6039ms).

On the other hand, the scrambling factor is combined with the dative NP's reanalysis in the transitive-ambiguous condition (22c). It is a different problem whether scrambling combined with reanalysis can affect comprehension. In a later section, I will consider how the effect of reanalysis without scrambling can be observed within the present experiment's framework.

3. Reanalysis and Regression

When readers read the disambiguating matrix verb, the previous analysis should be checked with the matrix verb information. If the previous analysis does not fit with verb information, reanalysis should occur. In the present experiment, the transitive-ambiguous condition(22c) should be reanalyzed because the previous analysis including a

dative argument is inconsistent with the transitive verb information. To reanalyze the phrase structure, it is required to activate the dative NP. If the dative NP is not available in working memory, it should be retrieved, which may result in a quick regression. The distinctive feature of the present experiment is the high regression-out probability in the transitive-ambiguous condition. The high regression-out probability may result from unavailability of necessary information for reanalysis. If this is the case, a quick regression may lead to the shorter reading times in the matrix verb region.

With respect to reanalysis and regression, one factor to consider is the sentence wrap-up effect because the disambiguating region, the matrix verb, always appears in the end position of a sentence, reflecting the head-final property. Just & Carpenter (1980) proposed that wrap-up occurs when readers reach the end of a sentence. This wrap-up is concerned with the search for referents that have not been assigned, resolution of within-sentence inconsistencies, and construction of interclausal connections.

In the present experiment, the size of the wrap-up effect may be affected by reading strategies. The high regression-out probabilities show that reading is not completed when the matrix verb is entered. As said above, if

the high regression-out probability in the transitive-ambiguous condition represents a quick regression due to reanalysis, the reading times of the matrix verb region in the transitive-ambiguous condition may include a smaller wrap-up effect than those in other conditions.

In sum, reanalysis of the dative NP might lead to a quick regression, resulting in the smaller wrap-up in the transitive-ambiguous condition compared to other conditions. If this is the case, regression-out probability might be a better index for comprehension difficulty than the reading times.

4. Local Complexity in the Matrix Verb Region

With respect to the measure of reading times in the matrix verb, local complexity should be considered. Specifically, the sentences of the present experiment consist of two clauses, the main clause and the relative clause. Local complexity may result from the closure of a clause. The relative clause is closed when the relative head is input. The main clause is closed when the matrix verb is encountered. Complexity may be greater when the relative head and the matrix verb occur in immediate succession. In the present experiment, the relative head immediately precedes the matrix verb in all conditions except the

dative-unambiguous condition (22b). The dative-unambiguous condition can be called a one-clause end condition (22b). In contrast, the other conditions can be called two-clause end conditions (22a, 22c, and 22d). If two-clause end conditions lead to local complexity compared with a one-clause end condition, it may be difficult to directly compare the four conditions above. The difficulty of dative-unambiguous (22b) may be underestimated. If it had been more difficult than observed, the results would have approached the prediction of garden-path theory more closely.

B. The Comparison between the Present Study and a Recent Study

Hirose's (1995) study is very similar to the present experiment in the sense that both studies focused on the ambiguity of the dative NP with respect to the reanalysis of a relative clause. Consider (19) again.

(19)a.Michiko-ga itoko-ni ring-o ageta shoojo-o
-Nom cousin-Dat apple-Acc gave girl-Acc
tomodachi-ni shookaishita.
friend-Dat introduce

Initially the dative NP, *itoko-ni*, is attached to the current clause. The focus of Hirose's study is whether the dative NP is expelled or not when the relative head, *shoojo-o*, is encountered. If the dative NP (as well as the nominative NP) is expelled when the relative head is encountered, the reading times of the second dative NP should be longer than the control sentences. In the control sentences, the first dative NP appears after the accusative NP, which means that the first dative NP is guaranteed to be a constituent of the relative clause. But Hirose found that the reading times of the second dative NP in the experimental sentences were as fast as that in the control sentences. This result supports the minimal expulsion theory.

The main difference between Hirose's and the present experiment's sentences is whether a second nominative NP exists after the dative NP. Consider (22a) again.

(22) a.dative-ambiguous condition

emeni-ka eppun maknayddal-eykey [samchon-I sacwu-n] cha-lul poecwuessda.

Mother-Nom pretty youngest-daughter-Dat [uncle-Nom buy-rel] car-Acc showed.

"Mother showed to the pretty youngest-daughter the car which uncle bought (for her)."

In the sentence above, the second NP-Nom projects a new clause (complement or relative clause) and there are optional strategies for what to do with material that had been analyzed in an earlier clause, when the relative dative verb is encountered. That is, either the NP-Dat can be taken as filling its dative argument or empty categories can be postulated. The movement of the NP-Dat from its initial clause to the new clause projected by the second NP-Nom requires the assumption that scrambling is permitted in reanalysis. The strategy to postulate empty element permits the NP-Dat to remain in unscrambled position in its initial clause. The present experiment found that the total reading times in the matrix verb in the transitive-ambiguous condition were longer than those in the dative-ambiguous condition, suggesting that the latter strategy (empty element) is preferred.

C. Reanalysis and Comprehension Difficulty in a Head-final Language

With respect to comprehension difficulty in head-final languages, many theories have different perspectives.

Garden-path theory (Frazier and Rayner, 1982) assumes that reanalysis produces some degree of processing difficulty. An information-paced approach (Inoue and Fodor, 1994) proposes that comprehension difficulty depends on whether other constituents overlay the previous thematic role of reanalyzed constituent. The lexical-based approach (Pritchett, 1988, 1991) claims that reanalysis leads to comprehension difficulty only when the reanalyzed constituent is interpreted outside the original theta-domain.

With respect to the dative NP's analysis in the present experiment, garden-path and information-paced theory make the same prediction for the reanalysis condition, the transitive-ambiguous condition. On the other hand, Inoue and Fodor (1995) proposed that processing difficulty depends on the required operation for reanalysis. One operation is 'steal', which means that the constituent is moved into a new domain though it can satisfy well-formedness in the previous position. The other operation is 'expel', which means that the constituent is moved into another place because it does not satisfy well-formedness in the present position. Inoue and Fodor (1995) claimed that the 'expel' operation is not costly though the 'steal' operation is costly. The example (7b) which supports Inoue and Fodor's idea has an optional transitive verb in the subordinate clause.

(7b) After John drank the water tasted bad.

That is, the original theta role can be maintained in the subordinate clause of the example above. It means that the required operation in (7b) is 'steal'. However, in the present experiment, the theta role of the dative NP cannot be maintained since the main verb is not an optional dative but a pure transitive verb. That is, the required operation is 'expel'. So, the information-paced approach appears to predict no comprehension difficulty in this experiment.

As argued earlier, the lexical-based theory is totally different from garden-path and information paced theory in reanalysis processes, because the arguments or adjuncts cannot be attached to the current phrase marker until a verb is given. Lexical-based theory predicts that the dative-ambiguous condition (22a) should be reanalyzed with difficulty compared with other conditions. According to this theory, comprehension difficulty occurs when the reanalyzed constituent is interpreted outside the previous theta domain. In the present experiment, the theory would claim that the dative NP that is first attached to the relative verb has to be moved into the main clause, which means that the dative NP should change its theta-domain. The results of

the present experiment do not seem to support the basic prediction of lexical-based theory.

On the other hand, Mazuka and Itoh (1995) proposed that only reanalyses combined with other complexity such as multiple syntactic reanalysis or lexical ambiguity lead to comprehension difficulty in Japanese(25).

(25)Yoko-ga kodomo-o koosaten-de mikaketa
Name-Nom child-Acc intersection-Loc saw
takusii-ni noseta.
taxi-Dat put-on
[NPi-Nom NP-Acc [ei ej V]Npj-Dat V]
"Yoko made the child ride the taxi that (she)saw at the intersection."

In the sentence above, the nominative NP and the accusative NP are first attached to the relative verb. Later, these two NPs turn out to be the arguments of a main clause. As seen earlier, Suh(1995) showed comprehension difficulty in this type of sentence. Considering Mazuka and Itoh's claim, the dative NP of the transitive-ambiguous condition (22c) is combined with a possible source of complexity, scrambling. How can the scrambling effect be controlled? Within the present experiment's framework, a double-layer relative clause can be appropriate. Consider (26)

(26)a.Youngsoo-ka chinkoo-eykey emeni-ka sachu-n
Name-Nom friend-Dat [[mother-Nom buy-rel]
os-ul choaha-nun eydonsang-ul sokaehassda
clothes-Acc like-rel] sister-Acc introduce
"Youngsoo introduced to the friend the sister who was wearing the clothes that mother bought (for her)."

b.Youngsoo-ka chinkoo-eykey emeni-ka sachu-n
Name-Nom [friend-Dat [mother-Nom buy-rel]
os-ul boyechukoiss-nun eydonsang-ul boassda.
clothes-Acc Show-rel] sister-Acc see
"Youngsoo saw the sister who was showing to the friend the clothes that mother bought (for her)."

c.Youngsoo-ka chinkoo-eykey emeni-ka sachu-n
Name-Nom friend-Dat [[mother-Nom buy-rel]
os-ul boeychukoissnun eydonsang-ul sokaehassda
clothes-Acc show-rel] sister-Acc introduce
"Youngsoo introduced to the friend the sister who was showing the clothes that mother bought (for her)."

The experimental logic is the same as the present experiment. The dative NP can attached to the main, to the lower, or to the higher relative clause. Finally, the dative NP is attached to the main clause in (26a), and (26c). In (26b), it is attached to the higher relative clause.

According to lexical-based theory, the reading times of the matrix verb in (26a) should be longer than those in (26b). In (26a), the NP-Dat is initially attached to the lower relative clause verb. It has to move from the lower relative clause to the main clause when the dative matrix verb is encountered. However, in(26b), the dative NP is initially attached to the lower relative clause. When the dative verb of the higher clause is encountered, the dative NP is moved into the higher relative clause. When the matrix verb is encountered, the possible arguments of the main clause are NP-Nom and NP-Acc. So, the transitive main verb does not lead to comprehension difficulty in (26b).

However, garden-path theory predicts no reading times difference at the main verb between (26a) and (26b). In (26a), the dative NP is initially attached to the clause projected by the first NP-Nom. When the lower relative clause verb is encountered, NP-Nom and NP-Dat is located outside the lower relative clause. When the higher relative verb is encountered, the possible argument are NP-Nom, NP-Dat, and NP-Acc. NP-Nom and NP-Dat is expelled because the higher relative verb is a pure transitive verb. Finally, the possible arguments for the following verb, matrix verb are NP-Nom, NP-Dat, and NP-Acc. Therefore, processing difficulty does not occur when the matrix verb is dative (26a). In

(26b), the dative NP is initially attached to the clause projected by the first nominative NP. When the lower relative clause verb is encountered, the dative NP is still attached to the initial clause. The potential arguments for the following verb, the higher relative clause verb, are NP-Nom, NP-Dat, and NP-Acc. Because the higher relative verb is a dative verb, only NP-Nom is expelled. Finally, the potential argument for the matrix verb is NP-Nom and NP-Acc. Therefore, comprehension difficulty does not occur when the matrix verb is transitive.

In (26c), both garden-path and lexical-based theory may predict comprehension difficulty because the dative NP attached to the verb, *boeychnun*, has to be moved into the main clause. In this example, reanalysis is not combined with scrambling or lexical ambiguities though the index of pro may be changed.

D. Verb Information and Reanalysis in a Head-final Language

In head-final languages, whether verb information is immediately used has not been studied much. This question is very important in the sense that it can show how the language processor and other cognitive processors are

interfaced. In head-final languages, this kind of problem might be studied in the reanalysis of the relative clause. Consider (27).

(27) a. Youngsoo-ka chaek-ul bokoissnun ae-ekesu
Name-Nom book-Acc read-ing-rel child-from
ppaeessda.
snatched

b. Youngsoo-ka chaek-ul miwehanun ae-ekesu
Name-Nom book-Acc hate-ing-rel child-from
ppaeessda.
snatched

Mazuka & Itoh (1995) and Suh (1994) showed that the reanalysis of sentences like (27a) is costly. In (27b), the verb ' miwehanun' must have a human object. If this information is immediately used, the reading of the matrix verb in (27a) should be more difficult than that of (27b), because the accusative NP in (27a) is already attached to the relative clause.

E. Conclusion

The present experiment examined the ambiguity of the dative NP, which means a dative NP that can be attached

either to the main verb or to the relative verb. On the basis of this ambiguity, this experiment tested the garden-path and the lexical-based theories. Garden-path theory assumes that the dative NP is immediately attached to the current phrase marker irrespective of the head. On the other hand, the lexical-based theory assumes that the dative NP can not be attached until a verb is given. Specifically, the form of the experimental sentences was the following: NP-Nom NP-Dat NP-Nom V-Dat NP-Acc V(dative or transitive). Garden-path theory predicts that processing difficulty occurs when the main verb is transitive. It is because the dative NP, which is already attached to the clause that is projected by the first nominative NP, must be moved into the relative clause when the transitive main verb is read. Lexical-based theory predicts that processing difficulty occurs when the main verb is a dative verb. This is because the dative NP is attached to the relative verb, though there is scrambling between the dative NP and the second nominative NP. The present experiment did not fully support garden-path theory. The interaction between matrix verb type (dative vs. transitive) and the dative NP's ambiguity (ambiguous vs. unambiguous) was not obtained. However, the results were much different from the prediction of lexical-based theory. The lexical-based theory predicts that the transitive-ambiguous condition (22c) should be easy compared with the

dative-ambiguous condition. However, the transitive-ambiguous condition was not easy compared with the dative-ambiguous condition in total reading times (105ms vs. 82ms per syllable) and regression-out probability in the matrix verb region (58% vs. 91%). With respect to the reanalysis of a relative clause, the results above showed that the parser does not compute scrambling, if not necessary.

I discussed the length effect, which might be the sources of unexpected processing difficulty of the transitive-unambiguous condition (22d) compared with the dative-unambiguous condition (22b). That length effect might lead to no interaction in the present experiment. Since Mazuka & Itoh (1995) propose that reanalysis combined with other complexity leads to the comprehension difficulty, I considered the control of scrambling combined with reanalysis by appealing to two-layer relative clauses within the present experiment's framework. In addition, I discussed local complexity in the matrix verb region with respect to the closure of the relative clause and the main clause. As a future study, I considered whether verb information such as selection restrictions can immediately be used in reanalysis of the relative verb.

APPENDIX

THE TRANSLATION OF EXPERIMENTAL SENTENCES

1 a.dative ambiguous and unambiguous condition

The office boy delivered to the young woman worker the paperwork which the teacher left.

b.transitive ambiguous and unambiguous condition

The office boy discovered the paperwork which the teacher left to the young woman worker.

2 a.dative ambiguous and unambiguous condition

The librarian showed off to his old fellow worker the hat which the shopworker delivered.

b.transitive ambiguous and unambiguous condition

The librarian stared at the hat which the shopworker deliverd to his old fellow worker.

3 a.dative ambiguous and unambiguous condition

The actor sent to the promising assistant director the adversing poster which the publicity agenda made.

b.transitive ambiguous and unambiguous condition

The actor saw the adversing poster which the publicity agent made for the promising assistant director.

4 a.dative ambiguous and unambiguous condition

The guide distributed to a lot of foreign tourists the book which the director introduced.

b.transitive ambiguous and unambiguous condition

The guide found the book which the director introduced to a lot of foreign tourist.

5 a.dative ambiguous and unambiguous condition

The secret agent sold to the dangerous hired killer the arms which the producer made.

b.transitive ambiguous and unambiguous condition

The secret agent searched for the arms which the producer made for the hired killer.

6 a.dative ambiguous and unambiguous condition

The liaison officer treated the well-dressed old person to the fruit which the soldier purchased.

b.transitive ambiguous and unambiguous condition

The liaison officer ate the fruit which the soldier purchased from the well-dressed old person.

7 a.dative ambiguous and unambiguous condition

The class teahcer gave out to the young primary-school children the lunch-box which the ladies prepared.

b.transitive ambiguous and unambiguous condition

The class teahcer inspected the lunch-box which the ladies prepared to the young primary-school children.

8 a.dative ambiguous and unambiguous condition

The executive director forwarded to the terrible moneylender the interest which the paymaster prepared and gave.

b.transitive ambiguous and unambiguous condition

The executive director didn't like paying the interest which the paymaster prepared and gave to the terrible moneylender.

9 a.dative ambiguous and unambiguous condition

The bank clerk showed the refined middle-aged customer the souvenir which the chief of the branch sent.

b.transitive ambiguous and unambiguous condition

The bank clerk stole the souvenir which the chief of the branch sent to the refined middle-aged customer.

10 a.dative ambiguous and unambiguous condition

The aunt informed the bald uncle about the hair drug that the dermatologist recommended.

b.transitive ambiguous and unambiguous condition

The aunt noted the hair drug that the dermatologist recommended to the bald uncle.

11 a.dative ambiguous and unambiguous condition

The head worker lent to the industrious apprentice the instrument which the section chief provided.

b.transitive ambiguous and unambiguous condition

The head worker coveted the instrument which the sectional chief provided to the industrious apprentice.

12 a.dative ambiguous and unambiguous condition

The businessman gave the mean powerful man the china which the nephew will present.

b.transitive ambiguous and unambiguous condition

The businessman inspected the china which he nephew will present to the mean powerful man.

13 a.dative ambiguous and unambiguous condition

The husband put on the scared young wife's the wedding-ring which the policeman found and returned.

b.transitive ambiguous and unambiguous condition

The husband kept the wedding-ring which the policeman found and returned to the scared young wife.

14 a.dative ambiguous and unambiguous condition

The explorer hand over to the old archeologist the meal which the assistant made.

b.transitive ambiguous and unambiguous condition

The explorer looked at the meal which the assistant made for the old archeologist.

15 a.dative ambiguous and unambiguous condition

Mother handed down to her pretty youngest daughter the car which Uncle bought.

b.transitive ambiguous and unambiguous condition

Mother liked the car which Uncle bought for his pretty youngest daughter.

16 a.dative ambiguous and unambiguous condition

The baseball manager handed out to the diligent athletes the sportswear which the coach recommended.

b.transitive ambiguous and unambiguous condition

The baseball manager carefully observed the sportswear which the coach recommended to the diligent athletes.

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